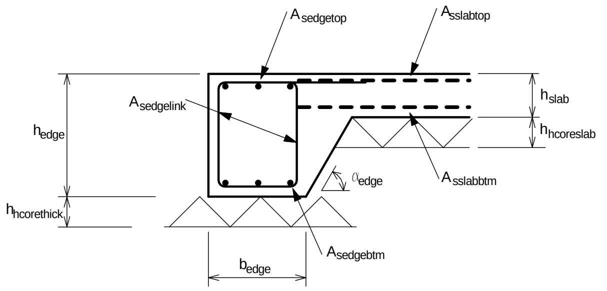
RAFT FOUNDATION DESIGN (BS8110 : Part 1 : 1997)

TEDDS calculation version 1.0.02;
Library item - Raft title



Soil and raft definition

Soil definition

Allowable bearing pressure; q_{allow} = **50.0** kN/m^2

Number of types of soil forming sub-soil; **Two or more types**

Soil density; **Firm**

Depth of hardcore beneath slab; $h_{hcoreslab}$ = **150** mm; (Dispersal allowed for bearing pressure check)

Depth of hardcore beneath thickenings; $h_{hcorethick}$ = **250** mm; (Dispersal allowed for bearing pressure check)

Density of hardcore; γ_{hcore} = **19.0** kN/m^3

Basic assumed diameter of local depression; $\phi_{depbasic}$ = **2500**mm

Diameter under slab modified for hardcore; $\phi_{depslab} = \phi_{depbasic} - h_{hcoreslab}$ = **2350** mm

Diameter under thickenings modified for hardcore; $\phi_{depthick} = \phi_{depbasic} - h_{hcorethick}$ = **2250** mm

Raft slab definition

Max dimension/max dimension between joints; l_{max} = **10.000** m

Slab thickness; h_{slab} = **250** mm

Concrete strength; f_{cu} = **40** N/mm^2

Poissons ratio of concrete; ν = **0.2**

Slab mesh reinforcement strength; f_{yslab} = **500** N/mm^2

Partial safety factor for steel reinforcement; γ_s = **1.15**

From C&CA document 'Concrete ground floors' Table 5

Minimum mesh required in top for shrinkage; **A142**;

Actual mesh provided in top; **A393 ($A_{sslabtop}$ = 393 mm^2/m)**

Mesh provided in bottom; **A393 ($A_{sslabbtm}$ = 393 mm^2/m)**

Top mesh bar diameter; $\phi_{slabtop}$ = **10** mm

Bottom mesh bar diameter; $\phi_{slabbtm}$ = **10** mm

Cover to top reinforcement; c_{top} = **50** mm

Cover to bottom reinforcement; c_{btm} = **75** mm

Average effective depth of top reinforcement; $d_{tslabav} = h_{slab} - c_{top} - \phi_{slabtop}$ = **190** mm

Average effective depth of bottom reinforcement; $d_{bslabav} = h_{slab} - c_{btm} - \phi_{slabbtm}$ = **165** mm

Overall average effective depth; $d_{slabav} = (d_{tslabav} + d_{bslabav})/2$ = **178** mm

Minimum effective depth of top reinforcement; $d_{tslabmin} = d_{tslabav} - \phi_{slabtop}/2$ = **185** mm

Minimum effective depth of bottom reinforcement; $d_{bslabmin} = d_{bslabav} - \phi_{slabbtm}/2$ = **160** mm

Edge beam definition

Overall depth; h_{edge} = **500** mm

Width;	b_{edge} = **500** mm
Angle of chamfer to horizontal;	α_{edge} = **60** deg
Strength of main bar reinforcement;	f_y = **500** N/mm^2
Strength of link reinforcement;	f_{ys} = **500** N/mm^2
Reinforcement provided in top;	**2 T20 bars ($A_{sedgetop}$ = 628 mm^2)**
Reinforcement provided in bottom;	**2 T20 bars ($A_{sedgebtm}$ = 628 mm^2)**
Link reinforcement provided;	**2 T10 legs at 250 ctrs (A_{sv}/s_v = 0.628 mm)**
Bottom cover to links;	c_{beam} = **35** mm
Effective depth of top reinforcement;	$d_{edgetop} = h_{edge} - c_{top} - \phi_{slabtop} - \phi_{edgelink} - \phi_{edgetop}/2$ = **420** mm
Effective depth of bottom reinforcement;	$d_{edgebtm} = h_{edge} - c_{beam} - \phi_{edgelink} - \phi_{edgebtm}/2$ = **445** mm

<u>**Internal slab design checks**</u>

Basic loading

Slab self weight;	w_{slab} = 24 kN/m^3 × h_{slab} = **6.0** kN/m^2
Hardcore;	$w_{hcoreslab} = \gamma_{hcore} \times h_{hcoreslab}$ = **2.9** kN/m^2

Applied loading

Uniformly distributed dead load;	w_{Dudl} = **0.0** kN/m^2
Uniformly distributed live load;	w_{Ludl} = **0.0** kN/m^2

Slab load number 1

Load type;	**Point load**
Dead load;	w_{D1} = **0.0** kN
Live load;	w_{L1} = **75.0** kN
Ultimate load;	$w_{ult1} = 1.4 \times w_{D1} + 1.6 \times w_{L1}$ = **120.0** kN
Load dimension 1;	b_{11} = **440** mm
Load dimension 2;	b_{21} = **440** mm

Internal slab bearing pressure check

Total uniform load at formation level;	$w_{udl} = w_{slab} + w_{hcoreslab} + w_{Dudl} + w_{Ludl}$ = **8.9** kN/m^2

Bearing pressure beneath load number 1

Net bearing pressure available to resist point load;	$q_{net} = q_{allow} - w_{udl}$ = **41.2** kN/m^2
Net 'ultimate' bearing pressure available;	$q_{netult} = q_{net} \times w_{ult1}/(w_{D1} + w_{L1})$ = **65.8** kN/m^2
Loaded area required at formation;	$A_{req1} = w_{ult1}/q_{netult}$ = **1.823** m^2
Length of cantilever projection at formation;	$p_1 = \max(0 \text{ m}, [-(b_{11}+b_{21}) + \sqrt{((b_{11}+b_{21})^2 - 4\times(b_{11}\times b_{21} - A_{req1}))}]/4)$
	p_1 = **0.455** m
Length of cantilever projection at u/side slab;	$p_{eff1} = \max(0 \text{ m}, p_1 - h_{hcoreslab} \times \tan(30))$ = **0.368** m
Effective loaded area at u/side slab;	$A_{eff1} = (b_{11} + 2 \times p_{eff1}) \times (b_{21} + 2 \times p_{eff1})$ = **1.385** m^2
Effective net ult bearing pressure at u/side slab;	$q_{netulteff} = q_{netult} \times A_{req1}/A_{eff1}$ = **86.6** kN/m^2
Cantilever bending moment;	$M_{cant1} = q_{netulteff} \times p_{eff1}^2/2$ = **5.9** kNm/m

Reinforcement required in bottom

Maximum cantilever moment;	$M_{cantmax}$ = **5.9** kNm/m
K factor;	$K_{slabbp} = M_{cantmax}/(f_{cu} \times d_{bslabmin}^2)$ = **0.006**
Lever arm;	$z_{slabbp} = d_{bslabmin} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{slabbp}/0.9)})$ = **152.0** mm
Area of steel required;	$A_{sslabbpreq} = M_{cantmax}/((1.0/\gamma_s) \times f_{yslab} \times z_{slabbp})$ = **89** mm^2/m

PASS - $A_{sslabbpreq}$ <= $A_{sslabbtm}$ - Area of reinforcement provided to distribute the load is adequate

The allowable bearing pressure will not be exceeded

Internal slab bending and shear check

Applied bending moments

Span of slab; $l_{slab} = \phi_{depslab} + d_{tslabav} = \mathbf{2540}$ mm

Ultimate self weight udl; $w_{swult} = 1.4 \times w_{slab} = \mathbf{8.4}$ kN/m^2

Self weight moment at centre; $M_{csw} = w_{swult} \times l_{slab}^2 \times (1 + \nu) / 64 = \mathbf{1.0}$ kNm/m

Self weight moment at edge; $M_{esw} = w_{swult} \times l_{slab}^2 / 32 = \mathbf{1.7}$ kNm/m

Self weight shear force at edge; $V_{sw} = w_{swult} \times l_{slab} / 4 = \mathbf{5.3}$ kN/m

Moments due to applied uniformly distributed loads

Ultimate applied udl; $w_{udlult} = 1.4 \times w_{Dudl} + 1.6 \times w_{Ludl} = \mathbf{0.0}$ kN/m^2

Moment at centre; $M_{cudl} = w_{udlult} \times l_{slab}^2 \times (1 + \nu) / 64 = \mathbf{0.0}$ kNm/m

Moment at edge; $M_{eudl} = w_{udlult} \times l_{slab}^2 / 32 = \mathbf{0.0}$ kNm/m

Shear force at edge; $V_{udl} = w_{udlult} \times l_{slab} / 4 = \mathbf{0.0}$ kN/m

Moment due to load number 1

Moment at centre; $M_{c1} = w_{ult1}/(4\times\pi) \times (1+\nu) \times \ln(l_{slab}/\min(b_{11}, b_{21})) = \mathbf{20.1}$ kNm/m

Moment at edge; $M_{e1} = w_{ult1}/(4\times\pi) = \mathbf{9.5}$ kNm/m

Minimum dispersal width for shear; $b_{v1} = \min(b_{11} + 2\times b_{21}, b_{21} + 2\times b_{11}) = \mathbf{1320.0}$ mm

Approximate shear force; $V_1 = w_{ult1} / b_{v1} = \mathbf{90.9}$ kN/m

Resultant moments and shears

Total moment at edge; $M_{\Sigma e} = \mathbf{11.2}$ kNm/m

Total moment at centre; $M_{\Sigma c} = \mathbf{21.1}$ kNm/m

Total shear force; $V_{\Sigma} = \mathbf{96.2}$ kN/m

Reinforcement required in top

K factor; $K_{slabtop} = M_{\Sigma e}/(f_{cu} \times d_{tslabav}^2) = \mathbf{0.008}$

Lever arm; $z_{slabtop} = d_{tslabav} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{slabtop}/0.9)}) = \mathbf{180.5}$ mm

Area of steel required for bending; $A_{sslabtopbend} = M_{\Sigma e}/((1.0/\gamma_s) \times f_{yslab} \times z_{slabtop}) = \mathbf{143}$ mm^2/m

Minimum area of steel required; $A_{sslabmin} = 0.0013 \times h_{slab} = \mathbf{325}$ mm^2/m

Area of steel required; $A_{sslabtopreq} = \max(A_{sslabtopbend}, A_{sslabmin}) = \mathbf{325}$ mm^2/m

PASS - $A_{sslabtopreq}$ <= $A_{sslabtop}$ - Area of reinforcement provided in top to span local depressions is adequate

Reinforcement required in bottom

K factor; $K_{slabbtm} = M_{\Sigma c}/(f_{cu} \times d_{bslabav}^2) = \mathbf{0.019}$

Lever arm; $z_{slabbtm} = d_{bslabav} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{slabbtm}/0.9)}) = \mathbf{156.7}$ mm

Area of steel required for bending; $A_{sslabbtmbend} = M_{\Sigma c}/((1.0/\gamma_s) \times f_{yslab} \times z_{slabbtm}) = \mathbf{310}$ mm^2/m

Area of steel required; $A_{sslabbtmreq} = \max(A_{sslabbtmbend}, A_{sslabmin}) = \mathbf{325}$ mm^2/m

PASS - $A_{sslabbtmreq}$ <= $A_{sslabbtm}$ - Area of reinforcement provided in bottom to span local depressions is adequate

Shear check

Applied shear stress; $v = V_{\Sigma}/d_{tslabmin} = \mathbf{0.520}$ N/mm^2

Tension steel ratio; $\rho = 100 \times A_{sslabtop}/d_{tslabmin} = \mathbf{0.212}$

From BS8110-1:1997 - Table 3.8;

Design concrete shear strength; $v_c = \mathbf{0.535}$ N/mm^2

PASS - v <= v_c - Shear capacity of the slab is adequate

Internal slab deflection check

Basic allowable span to depth ratio; $Ratio_{basic} = \mathbf{26.0}$

Moment factor; $M_{factor} = M_{\Sigma c}/d_{bslabav}^2 = \mathbf{0.775}$ N/mm^2

Steel service stress; $f_s = 2/3 \times f_{yslab} \times A_{sslabbtmbend}/A_{sslabbtm} = \mathbf{262.667}$ N/mm^2

Modification factor; $MF_{slab} = \min(2.0, 0.55 + [(477N/mm^2 - f_s)/(120 \times (0.9N/mm^2 + M_{factor}))])$

MF_{slab} = **1.616**

Modified allowable span to depth ratio; $Ratio_{allow} = Ratio_{basic} \times MF_{slab}$ = **42.021**

Actual span to depth ratio; $Ratio_{actual} = l_{slab}/ d_{bslabav}$ = **15.394**

PASS - $Ratio_{actual}$ <= $Ratio_{allow}$ - Slab span to depth ratio is adequate

<u>Edge beam design checks</u>

Basic loading

Hardcore; $w_{hcorethick} = \gamma_{hcore} \times h_{hcorethick}$ = **4.8** kN/m^2

Edge beam

Rectangular beam element; $w_{beam} = 24\ kN/m^3 \times h_{edge} \times b_{edge}$ = **6.0** kN/m

Chamfer element; $w_{chamfer} = 24\ kN/m^3 \times (h_{edge} - h_{slab})^2/(2 \times \tan(\alpha_{edge}))$ = **0.4** kN/m

Slab element; $w_{slabelmt} = 24\ kN/m^3 \times h_{slab} \times (h_{edge} - h_{slab})/\tan(\alpha_{edge})$ = **0.9** kN/m

Edge beam self weight; $w_{edge} = w_{beam} + w_{chamfer} + w_{slabelmt}$ = **7.3** kN/m

Edge load number 1

Load type; **Longitudinal line load**

Dead load; w_{Dedge1} = **4.0** kN/m

Live load; w_{Ledge1} = **0.0** kN/m

Ultimate load; $w_{ultedge1} = 1.4 \times w_{Dedge1} + 1.6 \times w_{Ledge1}$ = **5.6** kN/m

Longitudinal line load width; b_{edge1} = **140** mm

Centroid of load from outside face of raft; x_{edge1} = **0** mm

Edge beam bearing pressure check

Effective bearing width of edge beam; $b_{bearing} = b_{edge} + (h_{edge} - h_{slab})/\tan(\alpha_{edge})$ = **644** mm

Total uniform load at formation level; $w_{udledge} = w_{Dudl}+w_{Ludl}+w_{edge}/b_{bearing}+w_{hcorethick}$ = **16.1** kN/m^2

Centroid of longitudinal and equivalent line loads from outside face of raft

Load x distance for edge load 1; $Moment_1 = w_{ultedge1} \times x_{edge1}$ = **0.0** kN

Sum of ultimate longitud'l and equivalent line loads; ΣUDL = **5.6** kN/m

Sum of load x distances; $\Sigma Moment$ = **0.0** kN

Centroid of loads; $x_{bar} = \Sigma Moment/\Sigma UDL$ = **0** mm

Initially assume no moment transferred into slab due to load/reaction eccentricity

Sum of unfactored longitud'l and eff'tive line loads; $\Sigma UDLsls$ = **4.0** kN/m

Allowable bearing width; $b_{allow} = 2 \times x_{bar} + 2 \times h_{hcoreslab} \times \tan(30)$ = **173** mm

Bearing pressure due to line/point loads; $q_{linepoint} = \Sigma UDLsls/ b_{allow}$ = **23.1** kN/m^2

Total applied bearing pressure; $q_{edge} = q_{linepoint} + w_{udledge}$ = **39.2** kN/m^2

PASS - q_{edge} <= q_{allow} - Allowable bearing pressure is not exceeded

Edge beam bending check

Divider for moments due to udl's; β_{udl} = **10.0**

Applied bending moments

Span of edge beam; $l_{edge} = \phi_{depthick} + d_{edgetop}$ = **2670** mm

Ultimate self weight udl; $w_{edgeult} = 1.4 \times w_{edge}$ = **10.2** kN/m

Ultimate slab udl (approx); $w_{edgeslab} = \max(0\ kN/m, 1.4 \times w_{slab} \times ((\phi_{depthick}/2 \times 3/4) - (b_{edge} + (h_{edge} - h_{slab})/\tan(\alpha_{edge}))))$

$w_{edgeslab}$ = **1.7** kN/m

Self weight and slab bending moment; $M_{edgesw} = (w_{edgeult} + w_{edgeslab}) \times l_{edge}^2/\beta_{udl}$ = **8.5** kNm

Self weight shear force; $V_{edgesw} = (w_{edgeult} + w_{edgeslab}) \times l_{edge}/2$ = **15.9** kN

Moments due to applied uniformly distributed loads

Ultimate udl (approx); $w_{edgeudl} = w_{udlult} \times \phi_{depthick}/2 \times 3/4 = \mathbf{0.0}$ kN/m

Bending moment; $M_{edgeudl} = w_{edgeudl} \times l_{edge}^2/\beta_{udl} = \mathbf{0.0}$ kNm

Shear force; $V_{edgeudl} = w_{edgeudl} \times l_{edge}/2 = \mathbf{0.0}$ kN

Moment and shear due to load number 1

Bending moment; $M_{edge1} = w_{ultedge1} \times l_{edge}^2/\beta_{udl} = \mathbf{4.0}$ kNm

Shear force; $V_{edge1} = w_{ultedge1} \times l_{edge}/2 = \mathbf{7.5}$ kN

Resultant moments and shears

Total moment (hogging and sagging); $M_{\Sigma edge} = \mathbf{12.5}$ kNm

Maximum shear force; $V_{\Sigma edge} = \mathbf{23.4}$ kN

Reinforcement required in top

Width of section in compression zone; $b_{edgetop} = b_{edge} = \mathbf{500}$ mm

Average web width; $b_w = b_{edge} + (h_{edge}/\tan(\alpha_{edge}))/2 = \mathbf{644}$ mm

K factor; $K_{edgetop} = M_{\Sigma edge}/(f_{cu} \times b_{edgetop} \times d_{edgetop}^2) = \mathbf{0.004}$

Lever arm; $z_{edgetop} = d_{edgetop} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{edgetop}/0.9)}) = \mathbf{399}$ mm

Area of steel required for bending; $A_{sedgetopbend} = M_{\Sigma edge}/((1.0/\gamma_s) \times f_y \times z_{edgetop}) = \mathbf{72}$ mm^2

Minimum area of steel required; $A_{sedgetopmin} = 0.0013 \times 1.0 \times b_w \times h_{edge} = \mathbf{419}$ mm^2

Area of steel required; $A_{sedgetopreq} = \max(A_{sedgetopbend}, A_{sedgetopmin}) = \mathbf{419}$ mm^2

PASS - $A_{sedgetopreq}$ <= $A_{sedgetop}$ - Area of reinforcement provided in top of edge beams is adequate

Reinforcement required in bottom

Width of section in compression zone; $b_{edgebtm} = b_{edge} + (h_{edge} - h_{slab})/\tan(\alpha_{edge}) + 0.1 \times l_{edge} = \mathbf{911}$ mm

K factor; $K_{edgebtm} = M_{\Sigma edge}/(f_{cu} \times b_{edgebtm} \times d_{edgebtm}^2) = \mathbf{0.002}$

Lever arm; $z_{edgebtm} = d_{edgebtm} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{edgebtm}/0.9)}) = \mathbf{423}$ mm

Area of steel required for bending; $A_{sedgebtmbend} = M_{\Sigma edge}/((1.0/\gamma_s) \times f_y \times z_{edgebtm}) = \mathbf{68}$ mm^2

Minimum area of steel required; $A_{sedgebtmmin} = 0.0013 \times 1.0 \times b_w \times h_{edge} = \mathbf{419}$ mm^2

Area of steel required; $A_{sedgebtmreq} = \max(A_{sedgebtmbend}, A_{sedgebtmmin}) = \mathbf{419}$ mm^2

PASS - $A_{sedgebtmreq}$ <= $A_{sedgebtm}$ - Area of reinforcement provided in bottom of edge beams is adequate

Edge beam shear check

Applied shear stress; $v_{edge} = V_{\Sigma edge}/(b_w \times d_{edgetop}) = \mathbf{0.086}$ N/mm^2

Tension steel ratio; $\rho_{edge} = 100 \times A_{sedgetop}/(b_w \times d_{edgetop}) = \mathbf{0.232}$

From BS8110-1:1997 - Table 3.8

Design concrete shear strength; $v_{cedge} = \mathbf{0.454}$ N/mm^2

v_{edge} <= v_{cedge} + 0.4N/mm^2 - Therefore minimum links required

Link area to spacing ratio required; $A_{sv}\_upon\_s_{vreqedge} = 0.4\text{N/mm}^2 \times b_w/((1.0/\gamma_s) \times f_{ys}) = \mathbf{0.593}$ mm

Link area to spacing ratio provided; $A_{sv}\_upon\_s_{vprovedge} = N_{edgelink} \times \pi \times \phi_{edgelink}^2/(4 \times s_{vedge}) = \mathbf{0.628}$ mm

PASS - $A_{sv}\_upon\_s_{vreqedge}$ <= $A_{sv}\_upon\_s_{vprovedge}$ - Shear reinforcement provided in edge beams is adequate

<u>**Corner design checks**</u>

Basic loading

Corner load number 1

Load type; **Line load in x direction**

Dead load; $w_{Dcorner1} = \mathbf{4.0}$ kN/m

Live load; $w_{Lcorner1} = \mathbf{0.0}$ kN/m

Ultimate load; $w_{ultcorner1} = 1.4 \times w_{Dcorner1} + 1.6 \times w_{Lcorner1} = \mathbf{5.6}$ kN/m

Centroid of load from outside face of raft; $y_{corner1} = \mathbf{0}$ mm

Corner load number 2

Load type; **Line load in y direction**

Dead load; $w_{Dcorner2}$ = **4.0** kN/m

Live load; $w_{Lcorner2}$ = **0.0** kN/m

Ultimate load; $w_{ultcorner2} = 1.4 \times w_{Dcorner2} + 1.6 \times w_{Lcorner2}$ = **5.6** kN/m

Centroid of load from outside face of raft; $x_{corner2}$ = **0** mm

Corner bearing pressure check

Total uniform load at formation level; $w_{udlcorner} = w_{Dudl}+w_{Ludl}+w_{edge}/b_{bearing}+w_{hcorethick}$ = **16.1** kN/m^2

Net bearing press avail to resist line/point loads; $q_{netcorner} = q_{allow} - w_{udlcorner}$ = **33.9** kN/m^2

Total line/point loads

Total unfactored line load in x direction; $w_{\Sigma linex}$ = **4.0** kN/m

Total ultimate line load in x direction; $w_{\Sigma ultlinex}$ =**5.6** kN/m

Total unfactored line load in y direction; $w_{\Sigma liney}$ = **4.0** kN/m

Total ultimate line load in y direction; $w_{\Sigma ultliney}$ = **5.6** kN/m

Total unfactored point load; $w_{\Sigma point}$ = **0.0** kN

Total ultimate point load; $w_{\Sigma ultpoint}$ = **0.0** kN

Length of side of sq reqd to resist line/point loads; $p_{corner} =[w_{\Sigma linex}+w_{\Sigma liney}+\sqrt{((w_{\Sigma linex}+w_{\Sigma liney})^2+4 \times q_{netcorner} \times w_{\Sigma point})}]/(2 \times q_{netcorner})$

p_{corner} = **236** mm

Bending moment about x-axis due to load/reaction eccentricity

Moment due to load 1 (x line); $M_{x1} = w_{ultcorner1} \times p_{corner} \times (p_{corner}/2 - y_{corner1})$ = **0.2** kNm

Total moment about x axis; $M_{\Sigma x}$ = **0.2** kNm

Bending moment about y-axis due to load/reaction eccentricity

Moment due to load 2 (y line); $M_{y2} = w_{ultcorner2} \times p_{corner} \times (p_{corner}/2 - x_{corner2})$ = **0.2** kNm

Total moment about y axis; $M_{\Sigma y}$ = **0.2** kNm

Check top reinforcement in edge beams for load/reaction eccentric moment

Max moment due to load/reaction eccentricity; $M_{\Sigma} = \max(M_{\Sigma x}, M_{\Sigma y})$ = **0.2** kNm

Assume all of this moment is resisted by edge beam

From edge beam design checks away from corners

Moment due to edge beam spanning depression; $M_{\Sigma edge}$ = **12.5** kNm

Total moment to be resisted; $M_{\Sigma cornerbp} = M_{\Sigma} + M_{\Sigma edge}$ = **12.6** kNm

Width of section in compression zone; $b_{edgetop} = b_{edge}$ = **500** mm

K factor; $K_{cornerbp} = M_{\Sigma cornerbp}/(f_{cu} \times b_{edgetop} \times d_{edgetop}^2)$ = **0.004**

Lever arm; $z_{cornerbp} = d_{edgetop} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{cornerbp}/0.9)})$ = **399** mm

Total area of top steel required; $A_{scornerbp} = M_{\Sigma cornerbp} /((1.0/\gamma_s) \times f_y \times z_{cornerbp})$ = **73** mm^2

PASS - $A_{scornerbp}$ <= $A_{sedgetop}$ - Area of reinforcement provided to resist eccentric moment is adequate

The allowable bearing pressure at the corner will not be exceeded

Corner beam bending check

Cantilever span of edge beam; $l_{corner} = \phi_{depthick}/\sqrt{(2)} + d_{edgetop}/2$ = **1801** mm

Moment and shear due to self weight

Ultimate self weight udl; $w_{edgeult} = 1.4 \times w_{edge}$ = **10.2** kN/m

Average ultimate slab udl (approx); $w_{cornerslab} = \max(0\ kN/m, 1.4 \times w_{slab} \times (\phi_{depthick}/(\sqrt{(2)} \times 2)-(b_{edge}+(h_{edge}-h_{slab})/\tan(\alpha_{edge}))))$

$w_{cornerslab}$ = **1.3** kN/m

Self weight and slab bending moment; $M_{cornersw} = (w_{edgeult} + w_{cornerslab}) \times l_{corner}^2/2$ = **18.6** kNm

Self weight and slab shear force; $V_{cornersw} = (w_{edgeult} + w_{cornerslab}) \times l_{corner}$ = **20.7** kN

Moment and shear due to udls

Maximum ultimate udl; $w_{cornerudl} = ((1.4 \times w_{Dudl})+(1.6 \times w_{Ludl})) \times \phi_{depthick}/\sqrt{(2)}$ = **0.0** kN/m

Bending moment; $M_{cornerudl} = w_{cornerudl} \times l_{corner}^2/6$ = **0.0** kNm

Shear force; $V_{cornerudl} = w_{cornerudl} \times l_{corner}/2$ = **0.0** kN

Moment and shear due to line loads in x direction

Bending moment; $M_{cornerlinex} = w_{\Sigma ultlinex} \times l_{corner}^2/2$ = **9.1** kNm

Shear force; $V_{cornerlinex} = w_{\Sigma ultlinex} \times l_{corner}$ = **10.1** kN

Moment and shear due to line loads in y direction

Bending moment; $M_{cornerliney} = w_{\Sigma ultliney} \times l_{corner}^2/2$ = **9.1** kNm

Shear force; $V_{cornerliney} = w_{\Sigma ultliney} \times l_{corner}$ = **10.1** kN

Total moments and shears due to point loads

Bending moment about x axis; $M_{cornerpointx}$ = **0.0** kNm

Bending moment about y axis; $M_{cornerpointy}$ = **0.0** kNm

Shear force; $V_{cornerpoint}$ = **0.0** kN

Resultant moments and shears

Total moment about x axis; $M_{\Sigma cornerx} = M_{cornersw} + M_{cornerudl} + M_{cornerliney} + M_{cornerpointx}$ = **27.7** kNm

Total shear force about x axis; $V_{\Sigma cornerx} = V_{cornersw} + V_{cornerudl} + V_{cornerliney} + V_{cornerpoint}$ = **30.8** kN

Total moment about y axis; $M_{\Sigma cornery} = M_{cornersw} + M_{cornerudl} + M_{cornerlinex} + M_{cornerpointy}$ = **27.7** kNm

Total shear force about y axis; $V_{\Sigma cornery} = V_{cornersw} + V_{cornerudl} + V_{cornerlinex} + V_{cornerpoint}$ = **30.8** kN

Deflection of both edge beams at corner will be the same therefore design for average of these moments and shears

Design bending moment; $M_{\Sigma corner} = (M_{\Sigma cornerx} + M_{\Sigma cornery})/2$ = **27.7** kNm

Design shear force; $V_{\Sigma corner} = (V_{\Sigma cornerx} + V_{\Sigma cornery})/2$ = **30.8** kN

Reinforcement required in top of edge beam

K factor; $K_{corner} = M_{\Sigma corner}/(f_{cu} \times b_{edgetop} \times d_{edgetop}^2)$ = **0.008**

Lever arm; $z_{corner} = d_{edgetop} \times \min(0.95, 0.5 + \sqrt{(0.25 - K_{corner}/0.9)})$ = **399** mm

Area of steel required for bending; $A_{scornerbend} = M_{\Sigma corner}/((1.0/\gamma_S) \times f_y \times z_{corner})$ = **160** mm²

Minimum area of steel required; $A_{scornermin} = A_{sedgetopmin}$ = **419** mm²

Area of steel required; $A_{scorner} = \max(A_{scornerbend}, A_{scornermin})$ = **419** mm²

PASS - $A_{scorner} <= A_{sedgetop}$ - Area of reinforcement provided in top of edge beams at corners is adequate

Corner beam shear check

Average web width; $b_w = b_{edge} + (h_{edge}/\tan(\alpha_{edge}))/2$ = **644** mm

Applied shear stress; $v_{corner} = V_{\Sigma corner}/(b_w \times d_{edgetop})$ = **0.114** N/mm²

Tension steel ratio; $\rho_{corner} = 100 \times A_{sedgetop}/(b_w \times d_{edgetop})$ = **0.232**

From BS8110-1:1997 - Table 3.8

Design concrete shear strength; $v_{ccorner}$ = **0.449** N/mm²

$v_{corner} <= v_{ccorner}$ + 0.4N/mm² - Therefore minimum links required

Link area to spacing ratio required; $A_{sv}\_upon\_s_{vreqcorner} = 0.4N/mm^2 \times b_w/((1.0/\gamma_S) \times f_{ys})$ = **0.593** mm

Link area to spacing ratio provided; $A_{sv}\_upon\_s_{vprovedge} = N_{edgelink} \times \pi \times \phi_{edgelink}^2/(4 \times s_{vedge})$ = **0.628** mm

PASS - $A_{sv}\_upon\_s_{vreqcorner} <= A_{sv}\_upon\_s_{vprovedge}$ - Shear reinforcement provided in edge beams at corners is adequate

Corner beam deflection check

Basic allowable span to depth ratio; $Ratio_{basiccorner}$ = **7.0**

Moment factor; $M_{factorcorner} = M_{\Sigma corner}/(b_{edgetop} \times d_{edgetop}^2)$ = **0.314** N/mm²

Steel service stress; $f_{scorner} = 2/3 \times f_y \times A_{scornerbend}/A_{sedgetop}$ = **84.751** N/mm²

Modification factor; $MF_{corner}=\min(2.0,0.55+[(477N/mm^2-f_{scorner})/(120 \times (0.9N/mm^2+M_{factorcorner}))])$

MF_{corner} = **2.000**

Modified allowable span to depth ratio; $Ratio_{allowcorner} = Ratio_{basiccorner} \times MF_{corner}$ = **14.000**

Actual span to depth ratio; $Ratio_{actualcorner} = l_{corner} / d_{edgetop}$ = **4.288**

PASS - $Ratio_{actualcorner}$ <= $Ratio_{allowcorner}$ - Edge beam span to depth ratio is adequate